

CLAIMS

What is claimed is:

- 1 1. A method for forming a photonic-crystal filament, the method
2 comprising the steps of:
 - 3 a) mixing a slurry comprising particles of substantially uniform size and a
4 precursor material for a desired metal;
 - 5 b) urging the slurry through an orifice to force the particles and precursor
6 material into a combination having a desired crystallographic configuration;
 - 7 c) drying the combination emerging from the orifice; and
 - 8 d) sintering the precursor material, whereby a photonic-crystal filament is
9 formed.
- 1 2. A photonic-crystal filament made by the method of claim 1.
- 1 3. The method of claim 1, further comprising the step of:
2 e) compressing the slurry.
- 1 4. The method of claim 1, further comprising the step of:
2 f) heating the dried combination to remove the particles.
- 1 5. The method of claim 4, wherein the heating step f) and the sintering
2 step d) are performed simultaneously.
- 1 6. The method of claim 1, wherein the particles comprise an inert
2 material.
- 1 7. The method of claim 1, wherein the precursor material comprises a
2 metal oxide.
- 1 8. The method of claim 1, further comprising the step of:
2 g) reducing the precursor material to metallic form.

1 9. The method of claim 8, wherein step g) of reducing the precursor
2 material comprises heating the precursor material in a reducing environment.

1 10. The method of claim 9, wherein the reducing environment comprises
2 a gas selected from the list consisting of hydrogen, forming gas, a carbide gas,
3 acetylene, and mixtures thereof.

1 11. The method of claim 1, further comprising the step of:
2 h) providing a core filament and feeding the core filament through the
3 orifice while urging the slurry through the orifice to force the particles and
4 precursor material into a combination surrounding the core filament.

1 12. The method of claim 11, further comprising the step of:
2 i) passing an electric current through the core filament, whereby the core
3 filament is heated.

1 13. The method of claim 12, wherein the electric current heats the
2 precursor material to an effective temperature for sintering the precursor
3 material.

1 14. The method of claim 11, further comprising the step of:
2 j) removing the core filament after the precursor material is sintered.

1 15. The method of claim 1, further comprising the step of:
2 k) compressing the precursor material within a sheath.

1 16. The method of claim 15, wherein the sheath comprises a metal.

1 17. The method of claim 16, wherein the metal of the sheath comprises
2 copper.

1 18. The method of claim 15, wherein step k) of compressing the
2 precursor material is performed by drawing the sheath through at least one die.

1 19. The method of claim 18, wherein step k) of compressing the
2 precursor material is performed by drawing the sheath through a series of two or
3 more successively smaller dies.

1 20. The method of claim 15, wherein the sheath comprises a gas-
2 permeable material.

1 21. The method of claim 15, further comprising the step of:
2 l) removing the sheath after the precursor material is sintered.

1 22. The method of claim 15, further comprising the step of:
2 m) providing a core filament and feeding the core filament through the orifice
3 while urging the slurry through the orifice to force the particles and precursor
4 material into a combination surrounding the core filament and while
5 compressing the precursor material within the sheath.

1 23. The method of claim 22, further comprising the step of:
2 n) removing the sheath after the precursor material is sintered.

1 24. The method of claim 22, further comprising the step of:
2 o) removing both the sheath and the core filament after the precursor material is
3 sintered.

1 25. A photonic-crystal filament made by the method of claim 15.

1 26. The method of claim 1, wherein the desired metal is a refractory
2 metal.

1 27. The method of claim 27, wherein the refractory metal is selected
2 from the list consisting of tungsten, platinum, tantalum, molybdenum, and alloys
3 thereof.

1 28. The method of claim 1, wherein the desired metal is tungsten or an
2 alloy thereof.

1 29. The method of claim 1, wherein the precursor material comprises an
2 oxide of tungsten.

1 30. The method of claim 1, wherein the precursor material comprises
2 peroxopolytungstic acid.

1 31. The method of claim 1 wherein the particles comprise substantially
2 spherical particles.

1 32. The method of claim 1 wherein the particles comprise non-spherical
2 particles.

1 33. The method of claim 1 wherein the particles comprise polymer
2 particles.

1 34. The method of claim 1 wherein the particles comprise polymer
2 nanospheres.

1 35. The method of claim 34, wherein the polymer particles comprise a
2 material selected from the list consisting of polystyrene, polyethylene,
3 polymethylmethacrylate (PMMA), latex, and combinations thereof.

1 36. The method of claim 1, wherein the photonic-crystal filament has a
2 desired photonic band-gap, and the substantially uniform size of the particles is
3 adapted to provide the desired photonic band-gap.

1 37. The method of claim 37, wherein the desired photonic band-gap has
2 a lower wavelength edge and the substantially uniform size of the particles is
3 chosen to be about one-quarter the value of the lower wavelength edge of the
4 desired photonic band-gap.

1 38. The method of claim 37, wherein the desired photonic band-gap
2 corresponds to a wavelength between about 400 nanometers and about 7000
3 nanometers.

1 39. The method of claim 37, wherein the desired photonic band-gap
2 corresponds to a wavelength between about 1200 nanometers and about 1800
3 nanometers.

1 40. The method of claim 1, wherein the photonic-crystal filament has a
2 longitudinal axis and a selected crystallographic axis of the desired
3 crystallographic configuration is aligned parallel to the longitudinal axis of the
4 photonic-crystal filament.

1 41. A lamp filament made by the method of claim 1.

1 42. An incandescent lamp comprising a photonic-crystal filament made
2 by the method of claim 1.

1 43. A light source comprising the incandescent lamp of claim 43.

1 44. A method of cladding a metal filament, the method comprising the
2 steps of:

3 a) providing a metal filament;

4 b) mixing a slurry comprising particles of substantially uniform size and a
5 precursor material for a desired metal;

6 c) urging the metal filament and the slurry through an orifice to force the
7 particles and precursor material into a combination having a desired crystal
8 configuration surrounding the metal filament;

9 d) drying the combination emerging from the orifice;

10 e) sintering the precursor material; and

11 f) compressing the precursor material within a sheath, while drawing the
12 filament through a series of two or more successively smaller dies, whereby the
13 filament is clad with a photonic crystal.

1 45. The clad filament formed by the cladding method of claim 45.

1 46. The method of claim 45, further comprising the step of:

2 g) compressing the slurry.

1 47. The method of claim 45, further comprising the step of:

2 h) heating the dried combination to remove the particles.

1 48. The method of claim 48, wherein the heating step h) and the sintering
2 step e) are performed simultaneously.

1 49. The method of claim 45, wherein the particles comprise an inert
2 material.

1 50. The method of claim 45, wherein the precursor material comprises a
2 metal oxide.

1 51. A photonic crystal for covering a filament core, the photonic crystal
2 comprising:

3 a first refractory metal substantially filling interstitial spaces between a set
4 of substantially spherical voids disposed in a predetermined crystallographic
5 lattice,

6 the set of spherical voids being disposed surrounding the filament core.

1 52. The photonic crystal of claim 52, wherein the filament core
2 comprises a second refractory metal.

1 53. The photonic crystal of claim 53, wherein the first and second
2 refractory metals comprise different metals.

1 54. The photonic crystal of claim 53, wherein the first and second
2 refractory metals comprise the same metal.

1 55. The photonic crystal of claim 53, wherein the first and second
2 refractory metals both comprise tungsten or an alloy thereof.

1 56. The photonic crystal of claim 52, further comprising a filling material
2 disposed within the spherical voids, the filling material differing in refractive
3 index from the first refractory metal.

1 57. The photonic crystal of claim 57, wherein the filling material
2 substantially fills the spherical voids.

1 58. The photonic crystal of claim 52, wherein the filament core has a
2 longitudinal axis and a selected crystallographic axis of the predetermined
3 crystallographic lattice is aligned parallel to the longitudinal axis of the filament
4 core.

1 59. The photonic crystal of claim 52, wherein the first refractory metal
2 comprises tungsten or an alloy thereof.

1 60. A method of using a photonic crystal to reduce emission of selected
2 wavelengths of radiation from a filament, the method comprising the steps of:
3 a) providing a core filament and an electrical input connected to the core
4 filament; and

5 b) cladding the core filament with a photonic crystal material which is
6 operable to reduce emission of selected wavelengths of radiation during the
7 resistance heating of the filament when electrical energy is conducted to the
8 input and to the core filament.

1 61. The method of claim 61, wherein the core filament has a longitudinal
2 axis and the photonic crystal material has crystallographic axes, the method
3 further comprising the step of aligning a selected one of the crystallographic
4 axes of the photonic crystal material parallel to the longitudinal axis of the core
5 filament.

1 62. A method for filtering light from a light source having a longitudinal
2 axis, comprising the steps of:

3 a) providing a photonic crystal having a predetermined crystallographic
4 axis and a photonic band-gap adapted to block selected wavelengths of light;
5 and

6 b) surrounding the light source with the photonic crystal while aligning the
7 predetermined crystallographic axis parallel to the longitudinal axis of the light
8 source.

1 63. A filament comprising, in combination:

2 a) elongated filamentary means for emitting radiation in a range of
3 wavelengths in response to resistance heating; and

4 b) means for filtering, surrounding the filamentary means for emitting
5 radiation, the filtering means comprising a photonic crystal, the photonic crystal
6 being disposed surrounding the filamentary means for emitting radiation, and
7 the photonic crystal having a band-gap adapted to reduce the emission of
8 selected wavelengths at least partially within the range of wavelengths.

1 64. An electrical device comprising:

2 a) a support,

3 b) a transparent envelope secured to the support and forming an
4 enclosure therewith,

5 c) a filament having a metal core portion, and

6 d) an input for electrical energy secured to the support and electrically
7 coupled to the filament, the metal core portion of the filament being coated with
8 a photonic crystal material which is effective in reducing emission of selected
9 wavelengths of radiation during the resistance heating of the filament when
10 electrical energy is conducted to the input and to the metal core portion of the
11 filament.

1 65. The electrical device of claim 65, wherein the selected wavelengths
2 of radiation are selected infrared wavelengths and the photonic crystal material
3 has a photonic band-gap corresponding to the selected infrared wavelengths.

1 66. The electrical device of claim 65, wherein the metal core portion of
2 the filament has a longitudinal axis, the photonic crystal material has
3 crystallographic axes, and a selected one of the crystallographic axes of the
4 photonic crystal material is aligned substantially parallel to the longitudinal axis
5 of the metal core portion of the filament.